DOCUMENT RESUME

ED 171 585 SE 027 820

AUTHOR Suydam, Marilyn N., Ed.
TITLE Investigations With Calculators: Abstracts and Critical Analyses of Research. Supplement.
INSTITUTION Calculator Information Center, Columbus, Ohio.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE Jun 79
CONTRACT 400-79-0025
NOTE 38p.; For related document, see SE 027 581

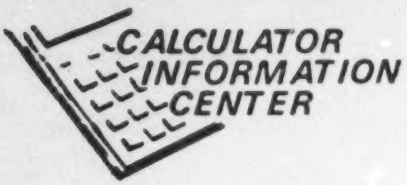
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Achievement; *Analytical Criticism; *Calculation; Elementary Secondary Education; Higher Education; Information Dissemination; Instruction; *Learning; *Mathematics Education; *Research Reviews (Publications); Teaching Methods
IDENTIFIERS *Calculators

ABSTRACT

This is a supplement to a previous collection of expanded abstracts of research with calculators. Eight dissertations are abstracted, to add to the fund of information on the effects of calculators on achievement and learning. The critical commentary prepared by each abstractor pinpoints particular strengths and weaknesses of each study. (MS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED171585



U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Marilyn N. Suydam

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Investigations with Calculators
Abstracts and Critical Analyses of Research

edited by

Marilyn N. Suydam

Director, Calculator Information Center

Supplement

June 1979

Calculator Information Center
The Ohio State University
1200 Chambers Road
Columbus, Ohio 43212

The work upon which this publication is based was performed pursuant to Contract No. 400-79-0025 of the National Institute of Education. It does not, however, necessarily reflect the views of that agency.

SE 027 820

Table of Contents

Page

Introduction
Marilyn N. Suydam, The Ohio State University iii

Aldridge, W. S. Effects of Electronic Calculators on Achievement of Middle School Remedial Mathematics Students. Unpublished doctoral dissertation, 1976.

Abstracted by George W. Bright, Northern Illinois University 1

Gallery, M. E. Teaching Calculator Use and Checking Account Skills to the Mildly Handicapped. Unpublished doctoral dissertation, 1978.

Abstracted by Robert E. Reys, University of Missouri at Columbia 4

Gooden, C. L. Some Effects of Using Minicalculators in an Arithmetic Course on the Attitude Towards Mathematics and the Mathematics Achievement of Community College Students. Unpublished doctoral dissertation, 1978.

Abstracted by Peggy A. House, University of Minnesota 7

Kobrin, B. The Hand-Held Calculator: Effects on Intermediate Grade Mathematics Achievement. Unpublished doctoral dissertation, 1978.

Abstracted by Robert E. Reys, University of Missouri at Columbia 12

Lunder, D. A. The Impact of the Calculator on Test Anxiety for High School Consumer Mathematics Students. Unpublished doctoral dissertation, 1978.

Abstracted by Peggy A. House, University of Minnesota 16

Spencer, J. N. Using the Hand-Held Calculator in Intermediate Grade Arithmetic Instruction. Unpublished doctoral dissertation, 1974.

Abstracted by E. Glenadine Gibb, The University of Texas at Austin 21

Whitaker, W. H. A Study in Change in Achievement, Interest, and Attitudinal Variates Accompanying the Use of Electronic Calculators in a First Grade Mathematics Curriculum. Unpublished doctoral dissertation, 1977.

Abstracted by E. Glenadine Gibb, The University of Texas at Austin 25

Wilson, A. W. The Effects of the Hand-Held Calculator upon Achievement Test Scores of Elementary School Mathematics Students. Unpublished doctoral dissertation, 1977.

Abstracted by George W. Bright, Northern Illinois University 30

Introduction to

Investigations with Calculators:

Abstracts and Critical Analyses of Research

Supplement

The abstracts and critical analyses of research in this document supplement those found in the January 1979 publication, Investigations with Calculators: Abstracts and Critical Analyses of Research. As was noted in the introduction to that document, they were prepared and compiled to add to the fund of information on the effects of hand-held calculators on achievement and learning. Since many persons find it difficult to secure original copies of all research studies, the expanded abstracts should provide specific information frequently not included in the brief abstracts found in, for instance, Dissertation Abstracts International or in the bulletins available from the Calculator Information Center. The critical commentary prepared by each abstractor pinpoints particular strengths and weaknesses noted for each study.

Thanks are extended to each of the abstractors who contributed to this publication. Their hours spent in reading dissertations, in abstracting, and in developing critiques will have been rewarded if they serve to help others in planning more effective investigations using calculators.

Marilyn N. Suydam
Director
Calculator Information Center

Aldridge, Wanda Scott. EFFECTS OF ELECTRONIC CALCULATORS ON ACHIEVEMENT OF MIDDLE SCHOOL REMEDIAL MATHEMATICS STUDENTS. (University of Georgia, 1976.) Dissertation Abstracts International 37A: 4078; January 1977. [Order No. 7629502]

Expanded abstract and analysis prepared especially for the Calculator Information Center by GEORGE W. BRIGHT, Northern Illinois University.

1. Purpose

The study was designed to determine the difference in achievement between remedial mathematics students who had access to electronic calculators and those who did not. Specifically, the hypotheses tested were (1) that access to calculators will result in higher posttest scores on an arithmetic basic skills test and (2) that there will be no significant difference in performance across grade levels.

2. Rationale

Two assumptions were made explicitly. First, any grade-by-treatment interactions were to be regarded as serendipitous. Second, the six teachers were considered to be competent to carry out the procedures.

In a reviewed study with seventh-grade (N = 87) and eighth-grade (N = 84) slow learners, the arithmetic drill and practice materials to be employed in the present study were found to be ineffective. Also, the use of calculators did not improve computation performance, when calculators were not allowed on the tests. Four other cited studies indicated mixed achievement results among calculator and non-calculator treatments. Too, attention was also given to the projections (not based on research) for massive use of calculators in the future.

3. Research Design and Procedures

The study was a methods-comparison study with pre- and posttests. Subjects were sixth graders (six groups, 55 students), seventh graders (six groups, 60 students), and eighth graders (four groups, 58 students) who were removed from regular classes for remedial instruction. For each of grades six and seven, two teachers individually taught three groups, and at grade eight two teachers team-taught the four groups. For each of grades six and seven, scheduling considerations dictated that one teacher's three groups were experimental and the other teacher's were control. In grade eight, one morning group and one afternoon group were assigned to

each of the experimental and control groups.

In March 1975, both groups were administered Basic Skills in Arithmetic Test, Form A as a pretest. On April 29, Form B was administered as a posttest. Students were not allowed to use calculators. This test measures all four operations with whole numbers, fractions, decimals, and percents. Reported reliabilities (computed on norming samples in 1945) were .86, .96, and .97 for grades six, seven, and eight, respectively.

Beginning on April 1, the experimental groups began an experimenter-developed learning packet (written and tape materials) on the use of the calculator. The control group worked the exercises from this packet using only paper and pencil. Each student worked individually, as this was the mode of instruction typically used with all groups. At the conclusion of this packet, each student began work in the Computational Skills Development Kit, with each student working individually. Each experimental group subject had access to a calculator, while no control group subject did. During the last two weeks of the four-week treatment, experimental group subjects were required to work prescribed problems without calculator assistance.

Analysis of covariance was used. The .05-level of significance was chosen.

4. Findings

The grade effect ($F = .94$, $df = 2,166$) was non-significant. The treatment effect ($F = 9$, $df = 1,166$) was significant. The control group performed better. The interaction effect ($F = 3.6$, $df = 2,166$) was significant. Posttest scores were highly correlated ($r = .78$, $p < .001$) with pretest scores. For grade six and seven, the control group outscored the experimental group [apparently significantly]; at grade eight the experimental group outscored the control group, but the difference was not significant.

Experimental and control groups completed, respectively, an average of 25 and 29 exercise cards in grade six, 19 and 25 cards in grade seven, and 31 and 23 cards in grade eight. These group comparisons exactly paralleled the achievement results.

5. Interpretations

Purchasing calculators for remedial mathematics students below the

eighth grade may not be justified. Eighth graders, however, may profit from calculator use.

Critical Commentary

1. Because of the emphasis in the rationale on projections for massive use of calculators by the general public, the focus of the experiment seems inappropriate. It would have made more sense, to this abstractor at least, to examine performance on the tests in the presence of calculators. For example, students from both treatment groups could have been randomly assigned to take the tests with or without use of calculators.
2. Of course the results must be viewed within the limitations of an individualized (independent study) course. This was not emphasized sufficiently in the discussion.
3. There is an uncontrolled and unacknowledged teacher effect. Even with the use of the same instructional materials across all groups, there is the possibility that the ways these materials were implemented varied across teachers.
4. Using the student as the unit of analysis seems inappropriate. The treatment did not start until April 1. Even though each student worked alone, it seems likely that during the period from September through March each group would have developed its own "personality". Students in a given group would, therefore, possibly react to a treatment in similar ways. Since each teacher was assigned to a treatment, in grades six and seven at least, the appropriate unit of analysis should be the mean score for all students of each teacher. The true N is thus too small to permit parametric analysis.
5. No indication was given of the time required to complete the packet on how to use the calculator.
6. The distributions of completed exercise cards (across the 16 units in the Kit) between the experimental and control groups seems sufficiently different to warrant post hoc analysis. The distributions by grade were not given.
7. The advantage of the control group over the experimental group was greatest at grade six, less at grade seven, and negative at grade eight. This is a fascinating result. More exploration of this seems called for.

Gallery, Michael Edward. TEACHING CALCULATOR USE AND CHECKING ACCOUNT SKILLS TO THE MILDLY HANDICAPPED. (Utah State University, 1978.) Dissertation Abstracts International 39A: 2866; November 1978. [Order No. 7821130]

Expanded abstract and analysis prepared especially for the Calcultor Information Center by ROBERT E. REYS, University of Missouri-Columbia.

1. Purpose

This research study had the following objectives:

a. To develop instructional packages designed to teach EMR pupils in secondary school to use a calculator to keep accurate checkbook records.

b. To evaluate the effectiveness of these instructional packages.

c. To determine the potential for transfer of calculator and checking account skills to the home.

d. To assess the exportability of the instructional packages.

2. Rationale

Little research has been done related to the application of calculator skills in solving consumer mathematics problems. Furthermore, no validated teaching package designed to teach EMR pupils to use calculators to solve basic consumer problems exists.

3. Research Design and Procedures

A five-stage R & D model was used in this study, namely: (a) definition, (b) design, (c) development, (d) dissemination, and (e) transfer validation of the package. This study used a nonequivalent control-group design. Both groups were pretested on the criterion referenced tests for calculator skills and checking account skills. The experimental groups received instruction on the calculator package and then on the banking package. The control group received no instruction in either area. Upon completion of the treatment, both groups were posttested.

Pretest scores on the criterion referenced tests were used as covariates to test hypotheses on the posttest data. A Likert scale was used with both pupils and teachers to learn their reactions to the instructional packages. A follow-up of parents of pupils in the experimental group was also made to ascertain their reactions to these instructional packages. Only descriptive statistics were used to describe the results of this stage of the study.

4. Findings

This study reported:

a. The experimental groups scored significantly higher (beyond .05) on the criterion referenced tests for the calculator package and on checking account skills than the control groups.

b. Neither instructional package was successful in preparing 80 percent of the students to master 100 percent of the package objectives.

c. Both packages received favorable reactions from students as well as teachers.

5. Interpretations

The researcher acknowledges that any evidence resulting from this study must be considered tentative. Nevertheless, this study suggests that merely exposing EMR students to the calculator was not as effective in overcoming common computational problems as providing direct systematic instruction.

Critical Commentary

In my judgment, this study offers no information which extends research in mathematics education. It suffers from a variety of ills and should be considered an exploratory study at best. Here are some specific concerns:

1. The sample size is small, namely 18 in the experimental group and 20 in the control. Furthermore, the number of teachers and/or parents involved in the evaluation process was very small.
2. The researcher states that although random assignment of the treatment was not done, "no biasing variables were apparent." In spite of such assurances, this factor is a limitation of this study and should temper any interpretation.
3. The five-stage design to develop the instructional packages seemed appropriate, but its actual implementation was questionable. For example, the tryout of the instructional packages (designed for EMR students) was done exclusively with one normal second grader and followed by a field test involving five EMR students. Since no form of the instructional packages was included in this dissertation, it is not clear what changes resulted from this feedback. Only sketchy comment was reported in

an appendix.

4. The most valuable single contribution of this study was the instructional packages that were eventually developed. Any evaluations of this research depends on thorough knowledge of these packages. It was disappointing to learn that these packages or even detailed descriptions of them were not included in the dissertation. They are housed in the archives of the Merrill Library at Utah State University. This lack of accessability represents a serious problem for anyone contemplating replication of this study or wanting to utilize these packages.

Gooden, Curtis Lee. SOME EFFECTS OF USING MINICALCULATORS IN AN ARITHMETIC COURSE ON THE ATTITUDE TOWARDS MATHEMATICS AND THE MATHEMATICS ACHIEVEMENT OF COMMUNITY COLLEGE STUDENTS. (Kent State University, 1978.) Dissertation Abstracts International 39A: 2800-2801; November 1978.

Expanded abstract and analysis prepared especially for the Calculator Information Center by PEGGY A. HOUSE, the University of Minnesota.

1. Purpose

The study sought to determine the effects of using a calculator on the attitude toward mathematics and the mathematics achievement of community college students in an arithmetic course.

2. Rationale

The investigator acknowledged the present and probable future impact of calculators on adults and children both in and out of school, and he assumed that calculators will be used as a regular component of mathematics instruction in order to develop and reinforce mathematical skills and ideas. The investigation sought to establish the following hypotheses:

a. Achievement would be significantly higher for students using calculators.
b. Students would not become dependent on the calculators.
c. Students using calculators would score significantly higher on a mathematics attitude test than would students not using calculators.

3. Research Design and Procedures

The study involved nine sections of "College Arithmetic" in a community college in a large midwestern urban area. The school has an open admissions policy, and students may or may not be high school graduates. Of the 220 Ss who were enrolled in the nine sections of a remedial arithmetic course, only 113 completed the one-quarter course. Data were analyzed only for this 51 percent who completed the course. The nine intact classes were randomly assigned to one of three treatments:

Control (C) (4 classes): Ss did not use calculators in class or on tests

Experimental (E1) (the number of classes is not clear): Ss used calculators at will; assigned exercises were the same as for the C classes.

Experimental (E2) (the number of classes is not clear): Ss used calculators at will; assigned exercises were intended to require the use of calculators for approximately 85 percent of the items.

Four teachers participated in the study; each taught one control class and one or two experimental classes.

Five of the nine classes were randomly selected to be pretested for attitude and achievement. (Pretested classes included two C, two E1 and one E2.) Attitude was measured with a modified version of Dutton's attitude scale which was adapted to a 5-point Likert format. The achievement measure was a test constructed by the school's mathematics faculty for use in the arithmetic course. Split-half reliabilities of the two instruments were reported to be .83 and .82 respectively. The rationale for pretesting only half of the students was to establish whether the pretest sensitized the Ss to the treatment in a way which caused them to respond differently on the posttest as compared to unpretested Ss. For both the achievement and the attitude measures, a 2x2 analysis of variance was performed using the following design:

	Calculator	No Calculator
Pretested	X_1	X_2
Unpretested	X_3	X_4

Column means were used to estimate the main effects of the treatment; row means provided an estimate of the main effects of pretesting; cell means gave an estimate of the interaction effects. When both main and interactive effects were nonsignificant, an analysis of covariance was performed on X_1 vs. X_2 using the pretest scores as the covariate. The posttest data also were tested using an analysis of variance. If both the analysis of covariance and the analysis of variance produced consistent results, more confidence could be placed in the findings.

To test dependence on the calculator, half of the experimental Ss were randomly selected and allowed to use the calculator on the achievement posttest. The remaining experimental Ss were not allowed to use calculators on the achievement posttest. An analysis of variance sought to determine if significant differences occurred among these two subgroups of experimental Ss and the control Ss.

4. Findings

An analysis of variance using the achievement pretest data of the

C, E1, E2, and combined experimental groups showed no significant differences among the groups. It was assumed that the groups were initially equivalent on the achievement variable. Similarly, an ANOVA using the attitude pretest data of the C, E1, and E2 groups indicated no significant differences among the groups on initial attitude toward mathematics.

Following the design outlined above, the 2x2 ANOVA showed no significant main effects or interaction effects among Ss on the achievement posttest. The subsequent analysis of covariance and ANOVA likewise showed no significant differences among the E1, E2, and C groups on the achievement posttest.

The results for the attitude posttest measure were similar to those for achievement: no significant main or interaction effects for the 2x2 ANOVA and no significant differences among the E1, E2, and C groups in either the analysis of covariance or the analysis of variance were found.

The only significant difference reported ($p < .05$) resulted from the ANOVA comparing the achievement of three groups: experimental Ss with and without the use of calculators on the posttest and the control Ss. To determine which differences were significant, pairwise comparisons of the three groups were performed using t-tests. The results indicated that experimental Ss using calculators on the posttest performed significantly better ($p < .01$) than control Ss (not using calculators).

5. Interpretations

The investigator drew the following conclusions relative to the first and third hypotheses:

a. Use of the minicalculator as an instructional and learning aid was no more effective than using pencil-and-paper techniques to increase mathematics achievement.

b. Use of the minicalculator as an instructional and learning aid did not result in significant changes in attitude toward mathematics.

Hence, the experiment failed to support either the first or the third hypotheses.

The investigator drew two conclusions from the significant difference observed between control Ss and experimental Ss using calculators on the posttest:

a. Use of the minicalculator as a learning and instructional aid does not result in any significant loss of proficiency in the ability of community college students to use paper-and-pencil techniques (no dependency resulted).

b. Community college students who use the minicalculator perform better on achievement tests than do community college students who use pencil-and-paper techniques only.

He interpreted the above as supporting Hypothesis Two.

Critical Commentary

The questions which the investigation sought to answer were straightforward and the design was a fairly conventional one. However, its contribution to the body of research on calculators is limited. For one thing, it is more difficult to establish hypotheses which are stated as expected outcomes than it is to reject the more conventional null hypotheses. Failure to establish the superiority of one treatment over another is not equivalent to concluding that the two are equally effective. It is particularly difficult to accept the investigator's conclusion that Ss using calculators perform better on achievement tests than those who do not when this result was observed only for half the Ss (Hypothesis Two) but not for the whole group (Hypothesis One).

Other questions are unanswered by the study. Among them are the following:

The attrition rate from the course was high (nearly 50 percent). Hence only "successful students" were included in the analysis. Is it reasonable to assume that they represent the population which the investigation sought to study? Also, were there differences in the drop-out rates between calculator users and non-users? A positive relationship between calculator use and course completion might in itself be a significant outcome.

Numbers are often hard to keep track of in this report. For example, of the five experimental classes it is not clear how many received treatment E1 and how many E2. Neither is it always clear which students were being grouped together in the analysis. At times E1 and E2 were treated separately; at other times they were combined, then regrouped according to whether they used or did not use calculators on the posttests.

Although the arithmetic achievement test is included in the appendix,

there is no identification of the specific concepts or skills it seeks to measure and no attempt to determine whether calculator usage has differential effects for certain concepts. Such questions would be interesting to pursue. It also appears that the same achievement measure was used for both pre and post assessments, although this also is not explicit.

However, the most significant unanswered questions would appear to result from the failure to distinguish adequately between the experimental treatments. The use of specially designed calculator problems would appear to be a significant variable, but it tends to be obscured in the analysis and/or the discussion. It would also help to know how the calculators were actually used in the experimental classes.

There is no question that calculators will be used in courses like "college arithmetic" as in all levels of mathematics. What we need now are studies that extend our knowledge of how effectively to incorporate the calculators into the curriculum and how best to match the curriculum, the technology and the students.

Kobrin, Beverly. THE HAND-HELD CALCULATOR: EFFECTS ON INTERMEDIATE GRADE MATHEMATICS ACHIEVEMENT. (Brigham Young University, 1978.) Dissertation Abstracts International 39A: 3354; December 1978. [Order No. 7823434]

Expanded abstract and analysis prepared especially for the Calculator Information Center by ROBERT E. REYS, University of Missouri-Columbia.

1. Purpose

The study sought to determine if different achievement in mathematics would be found between intermediate grade students whose regular mathematics classes included selected activities with hand-held calculators and those who did not.

2. Rationale

Although there have been an increasing number of calculator studies, very few have been at the upper elementary grades. In addition, most have been short-term, covering a period of four to eight weeks. Furthermore, the results from the previous research have been inconclusive on this issue. This background documents a need for a long-term study involving fourth, fifth, and sixth graders.

3. Research Design and Procedures

A non-randomized control group pretest-posttest design was utilized for this study from early October to the end of March. Three elementary schools from two school districts participated. A summary of the number of students by grades and treatment is shown below:

	Grade		
	4th	5th	6th
Calculator Treatment	24	46	50
Control	45	25	26

These numbers represent complete classes that were used as treatment groups, but it is not clear if random assignment of these classes was used. The Comprehensive Test of Basic Skills, Level 2, Test 7, Mathematics Concepts and Applications, Forms S and T were used for all criterion measures and subsequent data analysis.

All classes were taught by their regular classroom teacher. Use of calculators was prohibited in the control classes throughout the duration of the study, whereas calculator activities selected to

correlate with the regular mathematical topics were used in the experimental classes during two thirty-minute periods per week. Only one set of calculators was available, so they were shared among the experimental classes. The teachers of the experimental classes participated in a two-hour workshop on the use of calculators with the selected activities.

An analysis of covariance was done using pretest scores on the CTBS as a covariant and considering the posttest scores as the dependent variable. The same procedure was used to test eight hypotheses.

4. Findings

Hypotheses of significant differences (beyond .05) between the calculator and non-calculator classes were examined for the following variables:

a) mathematics achievement scores in intermediate grades
d) mathematics achievement scores of fourth grade classes
e) mathematics achievement scores of fifth grade classes
f) mathematics achievement scores of sixth grade classes
g) mathematics achievement scores of boys
h) mathematics achievement scores of girls
b) mathematics of high achievers in intermediate grades
c) mathematics achievement scores of low achievers in intermediate grades

The statistical analyses revealed no significant differences on any of these comparisons.

5. Interpretations

The following two conclusions were reported:

1. Mathematics achievement of pupils in intermediate grades were not affected by the use of hand-held calculators.
2. When grade level, sex, and level of achievement were considered, the mathematics achievement was not affected by the use of hand-held calculators.

Critical Commentary

This research focuses on a significant and timely issue, namely, the effect of hand-held calculators on pupils in intermediate grades. Unfortunately, it leaves so many unanswered questions and raises

enough serious concerns that the contribution of this study to mathematics education research is meager at best. In addition to no specified attempt to control for a Hawthorne effect among groups, here are some specific points to ponder:

1. Part of the justification for this research was the need for a long-term study, yet its duration was less than six months. This seems to be a contradiction but no explanatory comments were offered.
2. The stated purpose of this study was to examine mathematics achievement. It was broken into two categories, namely, applications and concepts, in the definition of terms section. Yet none of the later data analyses reflected anything except a single achievement measure. No explanation was given for for using only a single criterion measure. In fact, the validity of the instrument for the calculator group is open to question. Does the CTBS reflect some of the topics (estimation, negative numbers, decimals, very large numbers, etc.) that will naturally arise with calculator use? No mention was made of other important variables such as the affective domain. What effects did the calculator have on attitude and/or motivation for learning? Why weren't such dimensions considered in this research?
3. Only analysis of the CTBS was reported and discussed. Descriptive information regarding what actually happens in the classroom is desperately needed in calculator research, but none was reported. Information regarding the actual percent of calculator use, classroom management problems, changes in percent of children who had and used calculators at home, and anecdotal information from teachers reporting observational data related to calculator usage while working with children were not mentioned.
4. One question concerns the statistical analysis. Preliminary tests for comparability of groups on the pretest measure were not mentioned or explained. Only results from an analysis of covariance were reported. It was said to be nice to know.
5. A two-[illegible] calculator workshop was given to teachers in the treatment classes, but no placebo workshop was provided for the control group teachers. Furthermore, no agenda for this

workshop or details regarding its content other than it provided "use of the calculators with selected activities" were given. Such information is essential for anyone interested in using calculators in a school setting.

6. Instructional activities were designed for, and integrated into, the regular mathematics curriculum for the calculator classes. Clear and explicit characterization of the instructional activities is essential to any researcher examining these results. Since these activities constitute the heart of the instructional treatment, it is necessary that the set of activities--as they were used in the classroom--be available for careful inspection. Unfortunately, only a few sample activities are included in an appendix and even these are sketchy. Why wasn't the entire packet of materials included in the dissertation? It would also be valuable to have collected annotations from the classroom teachers describing the strengths and/or weaknesses of these activities along with teaching techniques that were sucessful in actually implementing the activities.
7. What about information about how calculators were actually used in the classroom? Was good instruction occuring? Did the teacher use the calculator effectively in the classroom? Were the calculators used as often as they were purported to be used? How was this documented? Were classroom observations made by the researcher? What percent of time of calculator use was spent on developing new concepts? Exploring patterns? Developing algorithms? Problem solving? Checking paper-and-pencil computation? Answers to these important questions were not found in this research report.

Lunder, Dennis A. THE IMPACT OF THE CALCULATOR ON TEST ANXIETY FOR HIGH SCHOOL CONSUMER MATHEMATICS STUDENTS. (University of Denver, 1978.) Dissertation Abstracts International 39A: 6607; May 1979. [Order No. 7910673]

Expanded abstract and analysis prepared especially for the Calculator Information Center by PEGGY A. HOUSE, University of Minnesota.

1. Purpose

The study focused on the impact of calculators on test anxiety among high school consumer mathematics students. It sought to determine whether there were sex differences in test anxiety; whether test performance differed among low-, moderate-, and high-anxious students; and whether there were interaction effects of sex, anxiety level, and calculator treatment on the pupils' test anxiety or test performance.

2. Rationale

Test anxiety can seriously impair the mathematics learning of students, particularly students with a history of past failures in mathematics. Educators have proposed that allowing pupils to use calculators on tests can reduce that anxiety and consequently improve performance.

3. Research Design and Procedures

The study was conducted in three senior high schools in a suburban California school district. Ten classes involving 159 pupils (78 boys, 81 girls) and six teachers participated in the study. Pupils, who were randomly assigned to classes, were from grades nine through twelve. The ten classes were assigned to four treatments (two experimental, two control) as follows:

C_1 (3 classes; N = 43): Ss did not use calculators

C_2 (2 classes; N = 33): Ss used calculators on posttest only

E_1 (2 classes; N = 33): Ss used calculators in class but not on posttest

E_2 (3 classes; N = 50): Ss used calculators in class and on posttest

The duration of the experiment was ten weeks.

In measuring anxiety, the investigator differentiated between state anxiety (A - State) and trait anxiety (A - Trait). A - State refers to

anxiety experienced in a particular situation (in this case, the taking of the mathematics achievement test), while A - Trait signifies a relatively stable disposition of an individual to perceive a wide range of stimuli as dangerous or threatening. Two assessments of text anxiety were made. The Test Anxiety Inventory (TAI) was administered as a pre-assessment to classify Ss as low, moderate, or high on test anxiety generally. (The classification criteria for boys and girls were determined by the test's developer.) The other assessment involved the A - State scale of the State-Trait Anxiety Inventory (STAI) and was administered immediately after the pupils took the pre and post achievement tests, thus giving an estimate of the degree of anxiety experienced in the experimental situation.

Two other instruments were used in the study: the numerical ability and verbal reasoning subtests of the Differential Aptitude Test (DAT) were taken as measures of the Ss' mathematical and verbal aptitude, and parallel forms of the Westinghouse PLAN* test in consumer, applied, and business mathematics were used for pre and post assessments of achievement.

In an attempt to control the Ss' use of the calculators, all assignments were completed in class. All teachers used the same lesson plans and followed the same daily schedule. Teachers with more than one class were assigned to different treatments for each section of the course.

The investigator advanced eight hypotheses which he analyzed using an analysis of covariance design taking mathematical and verbal aptitude as covariates. Four of the hypotheses concerned the main effects of calculator treatment and of sex and the interaction effects of sex with anxiety level (TAI score) and of sex with calculator treatment on the Ss' test anxiety as measured by the STAI A - State scale. The remaining four hypotheses considered the main effects of calculator treatment and of anxiety level and the interaction effects of sex with anxiety level and of sex with calculator treatment on the mathematics achievement score on the PLAN* test.

4. Findings

Six of the eight null hypotheses were retained. The investigator found no significant differences in posttest anxiety due to the main effects of either calculator treatment or sex or due to the interaction effects of sex with calculator treatment. He also found no significant differences in achievement due to the main effects of anxiety level or due to the inter-

action effects of either sex with anxiety level or sex with treatment.

There was a significant difference ($p < .05$) in achievement among the four treatment groups. The Newman-Keuls method of multiple comparison indicated that the E_2 group performed significantly better ($p < .05$) on the post-achievement test than did either the E_1 or the C_1 groups.

Significant differences ($p < .05$) in posttest anxiety were found due to the interaction effects of sex with anxiety level. Low-anxious girls scored significantly lower on test anxiety than high-anxious girls, moderate-anxious girls, or high-anxious boys ($p < .01$ for each). Low-anxious girls also scored significantly lower than low-anxious or moderate-anxious boys ($p < .05$ for each). Further, high-anxious girls scored significantly higher on test anxiety than did either low-anxious or moderate-anxious boys ($p < .01$ for each).

5. Interpretations

The experimenter offered the following interpretations of the findings:

a. The consumer mathematics course resulted in a significant improvement in overall mathematics achievement for Ss with unrestricted use of calculators compared with Ss not using calculators on the test.

b. Ss who used calculators daily in class had superior achievement scores compared to Ss using calculators on the posttest only.

c. Girls were higher on test anxiety than boys at every level, except low-anxious girls who were significantly lower than all other groups.

d. The study did not show that the use of the calculator reduces anxiety, but it did show that the calculator had a positive effect on learning.

e. Teachers indicated that they believed the calculator allowed more student interaction and enabled the teacher to give more individual assistance.

f. "Since the results of the study show that the two groups that used calculators on the post-mathematics achievement test made substantial gains over the two groups that did not use calculator, I can conclude that the length of time that a student uses the calculator does not have a significant effect on mathematics

achievement but rather that the student merely understands how to use the calculator and feels comfortable using it."

Critical Commentary

The study employed a standard design, and it appears from the report that the investigator took reasonable precautions to account for and/or control relevant variables. Perhaps that is why it was so disconcerting to read his interpretations. With the possible exception of the fifth interpretation, which is based on informal feedback from the teachers, the investigator's interpretations invite questions and challenges. Following are some of the points of contention:

It is true that Ss in group E_2 (with calculators) performed better on the post achievement test as compared to Ss in either C_1 or E_1 (no calculators), but posttest performance is not equivalent to "a significant improvement in overall mathematics achievement." Although all Ss were given the PLAN* pretest, no report is made of the use, if any, of those scores other than their correlation with other tests. Conclusions about "significant improvements" should be based on comparisons of gains, not on final test score alone (mathematical and verbal aptitude covariates notwithstanding).

The second implication, that Ss using calculators daily performed better on the test than Ss using calculators only on the posttest, fails to differentiate between statistically significant and non-significant differences. Both E_2 and E_1 groups had higher posttest means than C_2, but only one of these differences (E_2 vs. C_2) reached significance at the .05 level. The same applies to the third implication -- i.e., high-anxious and moderate-anxious girls had higher test anxiety than their male counterparts, but neither difference reached statistical significance. Although a result may have practical significance without reaching statistical significance, it is nevertheless incumbent upon the investigator to differentiate between the two.

The investigator's fourth and sixth implications raise questions about the calculator's effect on learning. There is no distinction made between understanding of the concepts and applications being tested and the ability to perform the necessary arithmetic. It is quite possible that there were no differences among the groups in their learning of the concepts, principles, and applications. Rather, the calculator users may have attained higher

achievement scores only on the basis of their greater accuracy in computation. This distinction on the criterion test could provide useful information. Without it, the conclusions suggested appear to be too general to defend on the basis of the given evidence.

Spencer, Joann Nora. USING THE HAND-HELD CALCULATOR IN INTERMEDIATE GRADE ARITHMETIC INSTRUCTION. (Lehigh University, 1974.) Dissertation Abstracts International 35A: 7048-49; May 1975.

Expanded abstract and analysis prepared especially for the Calculator Information Center by E. GLENADINE GIBB, The University of Texas at Austin.

1. Purpose

The purpose of this study was to investigate what effect an instructional treatment using the hand-held calculator would have on improving computational skills and reasoning ability of intermediate elementary school students in an open-concept elementary school.

2. Rationale

Recognizing that mathematics education has been guided by two points of view (mathematics as a tool and mathematics instruction as training students to reason correctly and sequentially in mathematical situations), a comprehensive view of elementary mathematics was proposed. This view acknowledged the need for computational skills, as well as for understanding of mathematics and the possible use of the calculator in the attainment of these purposes.

The general and somewhat sketchy review of the literature supported the need for using the calculator. As background, three research studies conducted with junior high students, one with fifth graders and one with third graders, were reviewed. From the review of the literature reported, support was found for the "new math" being a failure by producing students who are unable to compute mathematical problems, for the calculator serving as a motivational device for students who dislike and fear mathematics, for the calculator freeing students from laborious computations and thus allowing more time for developing reasoning skills and for the teacher to teach reasoning skills, for individuals to work at their own rate, and for students to become familiar with the use of machines in their daily work.

Impetus for the study seems to be provided by the need to seek ways to help elementary teachers lessen the time spent to help children attain a competent level in computational skills, the need for research in the use of the calculator below the sixth grade, and knowledge about what effects the use of the calculator might have on elementary school programs.

3. Research Design and Procedures

Eighty-four fifth- and sixth-grade children from multi-ethnic backgrounds and attending William Penn Elementary School (in Bethlehem, Pennsylvania) comprised the sample for the study. Ten boys and ten girls were randomly assigned to each of an experimental group and a control group at the fifth-grade level. Similarly, 11 boys and 11 girls were randomly assigned to each of an experimental group and a control group at the sixth-grade level. Thus, there were two treatment groups (experimental and control) at each grade level or a total of twenty-one boys and twenty-one girls in the experimental classes and in the control classes.

Prior to the treatment, a two-day workshop session was conducted by the investigator for the principal and the teachers for purposes of introducing the study, clarifying the rules and responsibilities of those involved in the study, reviewing the daily schedule and discussing the testing and evaluation procedures to be used throughout the study. A one-day workshop was conducted by the investigator for the students who were to participate in the study for purposes of introducing the study, discussing evaluation techniques, record keeping, and daily lessons. All students became familiar with using the hand-held calculator. Students were randomly assigned to treatments following this workshop. The Iowa Test of Basic Skills--Arithmetic Session (Concepts and Problem Solving), Form 1 was administered to the students during the week prior to the treatment. No time limits were set for taking the test and even the slowest student was allowed to complete the test.

Both treatment groups worked with identical computation worksheets prepared by the experimenter. The content of the treatment, according to the proposed schedule, included addition and subtraction (1 week); multiplication and division (2 weeks); fractions, percentages, and decimals (2 weeks); and averages and reading problems (1 week). At the beginning of the week each student received a folder that contained five arithmetic worksheets on each arithmetic skill. These worksheets were to be completed and corrected by the students. The experimental group used the hand-held calculators to solve their arithmetic problems. The control group received instructions in arithmetic skills and solved their problems without the aid of the calculator. Answer sheets were available to the students. The student's corrections were to be recorded on the student's progress chart. The investigator administered fifteen-minute quizzes to the students to both treatment groups during the second, fourth, and sixth weeks. These

results also were recorded on the student progress charts. The investigator taught the instructional sessions and was assisted periodically by the two classroom teachers. Each treatment period was 35-40 minutes four days a week for the the duration of the study.

Following the treatment, the Iowa Test of Basic Skills--Arithmetic Section, Form 2 was administered to all students in the study as the posttest. During the testing all children in the experimental classes were given a calculator to solve the problems. All children in the control group classes used paper and pencil to solve their problems. At the conclusion of the study, the students were given the opportunity to present their reactions about the study in written form.

Three hypotheses were tested at each of the two grade levels:

H_1: There is no significant difference between the mean gain score of the experimental group when compared with the mean gain score of the control group at each grade level in terms of arithmetic computation, reasoning, and total scores.

H_2: There is no significant difference between the mean gain score of the boys when compared with the mean gain score of the girls at each grade level in terms of arithmetic computation, reasoning, and total scores.

H_3: There is no significant interaction between the treatment and sex at each grade level in arithmetic computation, reasoning, and total scores.

To test the hypotheses, a two-way analysis of variance was performed. Treatment and sex were the independent variables. The gain score of each arithmetic subtest (Concepts and Problem Solving) and of the total test were used as dependent variables. The concept subtests was a measure of computation; the problem-solving subtest was a measure of reasoning.

4. Findings

The results of the analysis for Grade 5 showed that there was a significant difference between the treatment groups in favor of the experimental group on the gain scores of the reasoning test. No other significant differences were found in Grade 5.

The results of the analysis for Grade 6 showed a significant difference between the treatment group in favor of the experimental group on both computation and total arithmetic. The difference between the

treatments approached significance (.10 < .05 < .10) on reasoning ability in favor of the experimental group. No other significant differences were found in Grade 6.

5. Interpretations

Results of the analysis of data were interpreted to indicate that students in open-concept schools who receive instruction using the hand-held calculator can be expected to make greater gains in reasoning ability than students not using the hand-held calculator.

Critical Commentary

The study was not concisely reported and in some instances there was ambiguity. In particular, the reviewer had difficulty in ascertaining the specific nature of the instructional treatment. Although a sample of the pupil guide was included as well as a proposed schedule, it was not clear that the pupil guide was that received by all children regardless of treatment. If so, one wonders what effect the pictorial dialogue about using calculators had on those students who did not use the calculators and were confronted with worksheets of computation exercises. Also, it was not noted if the schedule was a reality. Although the investigator served as the instructor, no description was given about the length, frequency, and nature of the instruction for either the experimental group or the control group throughout the treatment. Finally, the conclusions drawn are based on gain scores as measured by the two subtests (Concepts and Problem Solving) of the Iowa Basic Skills Test. No discussion was provided acknowledging the limitations of gain scores or rationale for using these scores in light of their limitations. Thus, the validity of the conclusions is questionable.

Whitaker, William Howard. A STUDY IN CHANGE IN ACHIEVEMENT, INTEREST, AND ATTITUDINAL VARIATES ACCOMPANYING THE USE OF ELECTRONIC CALCULATORS IN A FIRST GRADE MATHEMATICS CURRICULUM. (University of Southern California, 1977.) Dissertation Abstracts International 38A: 97-98; July 1977.

Expanded abstract and analysis prepared especially for the Calculator Information Center by E. GLENADINE GIBB, The University of Texas as Austin.

1. Purpose

"The specific purpose of this study was to examine the effect that the use of calculators with first grade children had upon achievement, attitudes, and interests related to mathematics. On a more general scale this study was to serve as a beginning into much needed research into the curriculum possibilities of calculators with all levels of students in the area of mathematics." (p. 5)

2. Rationale

The importance of the study was perceived to be related to two concerns: the calculator as an economically practical instructional device and the decline in achievement on basic mathematics skills. The theoretical constructs for the study were based on the work of Cattell and Butcher for a framework of factors involving motivation, interest, and personality variables as well as personality factors for achievement prediction; Lewin's work concerned with mutual interdependence of multiple factors--a multidimensional view; and reinforcement theories of learning, especially the work of Skinner.

From the review of descriptive literature, areas of proposed hypotheses drawn largely from subjective conclusions were classified as motivation, remediation, and facilitation of learning. Hypotheses related to facilitation of learning were those of aiding the student in the discovery of principles, the added power of performing operations with larger numbers for providing insight into understanding the basic operations, simplification of computation, exploring mathematical properties, developing estimation skills, checking capabilities, and differentiation between the analysis of the problem and the calculation of the answer.

Two areas of research studies to investigate the effects of using calculators were reviewed. The unidimensional studies, primarily focusing on cognitive factors, were found to support expected improvement in reasoning.

The bidimensional studies primarily investigated achievement and attitude, for the most part with slow learners in mathematics and with students with learning difficulties. As a group, the results of the studies reviewed were inconclusive with respect to expected achievement gains and changes in attitudes that can be attributed to using calculators as an instructional device compared to not using them.

3. Research Design and Procedures

The research design was a quasi-experimental design of the nonequivalent control group type. The student sample consisted of all the first graders at General Hoyt Vandenberg Elementary School (in Wiesbaden, Germany). These students were children of military personnel and United States Government civilian employers. The four classroom teachers involved in the study were all of the first-grade teachers in the school. Each teacher (and class) was randomly assigned as an experimental or control group.

Prior to the treatment, the Mathematics Attitudinal Scale (MAS) adapted for primary children and the California Achievement Tests, Mathematics, Level I, Form A (CATM) were administered to all children as a pretest. Also a Computational Arithmetic Problems Test (CAP), consisting of 33 addition and subtraction problems in both horizontal and vertical arrangements, was administered to measure computation in a non-timed situation and to include the concepts of missing addend and missing subtrahend. This instrument was designed through a cooperative effort of the investigator and the teacher participants. The problems on this test were of four types: $a + b = x$, $a + x = b$, $a - b = x$, and $a - x = b$. The answer format was of the fill-in-the-box type found in classroom materials used with children at the primary level, and which had been used with these children.

The treatment for 30 class instructional days consisted of students completing daily a worksheet of 10 problems. Nine of these problems were of the $a + b = x$ or $a - b = x$ types. The tenth problem on each sheet was of the $a + b + c = x$ type. Upon completion of each worksheet, each child in the experimental group checked the accuracy of the answers on one of the nine electronic desk calculators located within the classroom. Although the control group had the same worksheets, they did not have the opportunity to check results on the calculator. Their results were checked by the teacher. Furthermore, students in the experimental group were allowed to use the calculators during "free" time of about one-half hour

per day. Any time a calculator was used, the student using it placed a check mark by his or her name on a log sheet. Total possible calculator contact was approximately 40 minutes daily for the 30 days of instruction.

Following the completion of the instruction, the achievement and attitudinal instruments again were administered to both groups. The time lapse between the administration of the pretest and posttest was 7 weeks and 3 days.

Seventeen hypotheses in the null form were tested. The first six hypotheses compared gain scores between the control group and the experimental group for significant differences at the .10 level on the following: (1) CAP Computation, (2) CATM Computation, (3) CATM Concepts, (4) CATM Problems, (5) CATM Total, and (6) MAS Attitude. The last eleven hypotheses tested for relationships among variables within the experimental group is follows:

(7) CAP attitude scores and their frequency of calculator usage,
(8) CAP achievement gain scores and the frequency of calculator usage,
(9) CATM concept gain scores and the frequency of calculator usage,
(10) CATM computation gain scores and the frequency of calculator usage,
(11) CATM problem gain scores and the frequency of calculator usage,
(12) CATM total gain scores and MAS attitude gain scores,
(13) CATM concept gain scores and MAS attitude gain scores,
(14) CATM computation gain scores and MAS attitude gain scores,
(15) CATM problem gain scores and MAS attitude gain scores,
(16) CATM total achievement gain scores and MAS attitude gain scores, and
(17) CAP achievement gain scores and MAS attitude gain scores.

The differences between the means were tested by use of the *t* test. The correlational hypotheses were tested by converting the Pearson Product-Moment correlation coefficients to *t* scores and then using the *t*-test methods.

4. Findings

Gains between the experimental group and the control group were found

to differ significantly (.10 level) on the Computational Arithmetic Problems test and on the problems gain scores of the California Achievement Test, in the direction of the experimental group, and on the concepts gain scores on the California Achievement Test in the direction of the control group.

Of the eleven relationships examined among variables within the experimental group, a significant (.10 level) relationship was found only for the interaction of gain in attitude and frequency of use of the calculator.

5. Interpretations

The results led to the following conclusions. The addition of a calculator to a first-grade instructional program could be expected to aid in achievement. This conclusion was tempered, however, by the fact that this instrument was not a standardized test. Also, the calculator can be expected to serve as an aid in teaching students to solve verbal problems. If the calculator is to become a part of the primary grade curriculum, however, special care should be taken to aid students' mathematics development in the area of conceptualization.

From the examination of variable interactions, it was concluded that students who found the calculator to be of interest showed positive gains in attitude toward mathematics.

Critical Commentary

The investigator carefully designed the study, randomly assigned treatments to teachers and their classes, and, according to the report, administered the tests appropriately for first-grade children. Weaknesses were found, however, in reporting and analyzing the data. Only two tables presenting the t-test results from intergroup hypotheses and the correlation and t-tests from intragroup hypotheses respectively were given in the report. Neither in the report nor in the appendices was there other accompanying data. Thus, it was impossible to ascertain similarities and differences between the experimental and control groups prior to the treatment on the three instruments and, likewise, following treatment. One must ask, "Why was it necessary to use gain scores for testing the hypotheses?" Although the investigator noted limitations of the study with respect to its brevity and the use of only four teachers, no mention was

made of giving any consideration to the limitations of using gain scores or the rationale for using gain scores in this study in light of their limitations. Thus, I must question the validity of the conclusions even beyond the tempering given by the investigator. Furthermore, theoretical constructs were provided for the study as well as a review of both descriptive and research literature related to the study. Yet no attempt was made to relate this background to the findings and/or conclusions of the study.

Wilson, Art Wendell. THE EFFECTS OF THE HAND-HELD CALCULATOR UPON ACHIEVEMENT TEST SCORES OF ELEMENTARY SCHOOL MATHEMATICS STUDENTS. (University of Montana, 1977.) Dissertation Abstracts International 39A: 2116; October 1978. [Order No. 7818154]

Expanded abstract and analysis prepared especially for the Calculator Information Center by GEORGE W. BRIGHT, Northern Illinois University.

1. Purpose

The study was designed to determine whether calculators, when used as instructional aids to the regular mathematics program, increase student achievement on tests of concepts, computation, and applications. Sex differences and interaction of sex and calculator use/non-use were also investigated.

2. Rationale

The lack of systematic research on the use of calculators was cited as one of the justifications for the study. No conceptual framework was presented as a unifying structure for interpretation of the literature reviewed.

Two major experimental assumptions were made. First, teachers were of comparable competence. Second, the treatment period was sufficient to eliminate any novelty effect of the calculators.

3. Research Design and Procedures

Teachers of the experimental groups had previously completed a formal course or workshop on the use of calculators. Teachers of the control groups had students of similar grade and ethnic and socioeconomic backgrounds as experimental groups. Teachers were from three geographically scattered communities in Montana.

Seven experimental and four control groups were selected, two experimental groups and one control group from each of grades three (N = 28, N = 14), four (N = 56, N = 56), and six (N = 32, N = 16), and one experimental group and one control group from grade five (N = 24, N = 17). [Data from grade four, however, are reported as two classes only.] Students in each class "were randomly selected for that particular class by the school district."

The Stanford Achievement Test, Primary Level III and Intermediate Levels I and II, Form A was the pretest; Form B was the posttest. Subtests included concepts, computation, and applications. Scaled scores, rather than raw scores, were used. The treatment period was 21 weeks for grade three, 22 weeks for grade four, 17 weeks for grade five, and 21 weeks for grade six. The experiment was conducted during the last half of the year.

At each grade, the procedures were similar. The pretest was administered during the first week. Experimental group teachers then introduced the use of calculators with one calculator for each two students. Calculators had not been used previously in class. Calculators were used in "checking pencil and paper work, motivational problems, games, and discovery exercises." Teachers also used calculators as an aid in teaching algorithms. Control group teachers did not allow use of calculators in class and discouraged use at home.

Experimental and control group teachers chose a two-week mathematics unit to teach during the treatment period. Pre- and post-tests were developed cooperatively and administered in all classes. Calculators were not allowed on the tests, although calculator use during instruction continued as before. The teachers were encouraged to communicate with each other to keep the time period and topics taught as similar as possible. Topics selected were multiplication by 6 (grade three), multiplication by a two-digit multiplier (grade four), decimal multiplication (grade five), and review of the year's work (grade six).

Following the two-week unit, the calculator use continued in experimental groups. At the end of the treatment period the posttest was administered. Contact with the teachers was maintained by telephone. "Visits to the schools involved were made occasionally."

4. Findings

Analysis of variance on gain scores by grade was used, with sex as a classification variable. The .05 level of significance was used. Analyses were conducted at each grade level for each of the three subtests of the Stanford Test and for the teacher-made tests. [At each of grades three and five, the same teacher-made test was used for pre- and posttests. At each of grades four and six, different tests were used. In

particular, at grade six, the pretest had 20 items and the posttest had 33 items.] At grades three and six, the ANOVA factors were treatment, class, and sex. The df for class seems incorrectly reported. At grades four and five, the factors were treatment and sex only. [The p-values are incorrectly reported; e.g., for F = .84, the p-value is given as $p < .05$, when $p > .05$ would be correct; for F = 31.02, the p-value is given as $p > .001$ when $p < .001$ would be correct. (Table 23).]

Only four (of 64) F-values were significant. The sex x treatment interaction was significant at grade five (teacher-made test) and at grade six (computation subtest). In both cases, males were favored in the experimental group, and females in the control group. Also at grade six, females outscored males on the application subtest and there was a class effect on the teacher-made test.

5. Interpretations

Calculators can be used as an instructional aid without adverse effects in grades three, four, five, and six.

Critical Commentary

1. The biggest difficulty with this study is that there is no clearly defined treatment. If we are to understand the effects of the use of calculators, we must clearly define the ways in which they are to be used. It is not sufficient to provide vague guidelines to teachers and then merely tell the teachers to use the calculators. Too, there was apparently no attempt to measure the actual usage of the calculators. Without clear knowledge of the time and ways the calculator was used, no conclusions can be reached about the effects of calculators.
2. There seems to be a potential teacher effect that was not controlled. The experimental group teachers were self-selecting in that they sought out a workshop/course on calculators. The control group teachers apparently did not have similar enthusiasm for expanding their teaching skills.
3. The students were not randomly selected. Since the study did not begin until the second half of the year, the unit of analysis at best should have been the class mean, not the individual student.

4. Some mention should have been made of the narrowness of topics for the two-week instructional units.
5. The use of gain scores is suspect.
6. The use of pre/posttests with different numbers of items (grade six) is certainly non-standard. Too, the small numbers of items creates low reliabilities. (Reliabilities should have been reported.)
7. The statistical inaccuracies in the tables caused this abstractor to lose confidence in the work. If such basic knowledge is misunderstood, how can the experimenter be expected to produce believable research?